Engineering and Science

Space—Where Now, and Why?

by Eugene Shoemaker

A pioneer lunar geologist, long involved in the space program, says we haven't yet learned how to use man in space.

For the past ten years, I have been going around the country talking up the space program—explaining why it was a good thing and why we ought to send men into space. Now, for the first time, I'm speaking against it. More specifically, I'm against the series of plans that have been presented to President Nixon by his space task force. I am deeply concerned about these plans and about the way the manned space program of NASA is going right now. This concern is part of the reason I am getting out of the program after I have met my commitments for the next two Apollo flights.

The report of the Presidential task force presented three principal options for the future space program, all of them with the goal of landing a man on Mars. These options differ mainly in the time at which the U.S. should attempt to meet that goal. The fast option is to put man on Mars in 1983, with an estimated cost of about $134 billion; the intermediate option is to achieve the Mars landing in 1986, at a total cost of about $97 billion (present-day dollars). The third option, without a specified price tag, is to take it easy, still going for that goal, but sometime after 1990.

The guts of the report, the plan for the *near* future, is to develop what Dr. George Mueller, Associate Administrator of NASA for Manned Space Flight, calls a space transportation system. This system is to be developed to a certain point at which we can decide we're ready to send a man to Mars. The plan for space transportation includes a big earth-orbiting space station. Shuttles take men from the earth to the space station, and from there they can go to other, more distant places. One of the potential ancillary parts of this plan is to place an orbiting space station around the moon; travelers could be shuttled from the earth-orbiting space station to the lunar-orbiting space station, and then shuttled from there to a base on the moon. The principal justification for building this elaborate system is to put a man on Mars.

Of course, the real reason that this scheme has been proposed is that NASA wants to build big, new systems in space. NASA, after all, is primarily a big engineering organization, a good engineering organization, and good engineers like to build things. Putting a man on Mars is the next logical step for the engineers, a technological step to continue the kind of business that NASA has been in up to now.

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NASA has just gone through an eight-year program of building a big system, primarily for the sake of building a big system. This program is called Project Apollo. It is instructive to see how this program came out.

If we go back to the beginning of Project Apollo, to President Kennedy's decision in 1961 to put an American on the moon, the rationale behind it went something like this: The Soviet Union had the jump on us with a very considerable lead in large launch vehicles. To upstage the Soviets and pull ahead of them, we had to plan far enough ahead to allow a fair chance to overcome that lead. The best bet was to plan a large long-range effort, such as landing a man on the moon. The decision by Congress to establish NASA in 1958 was made somewhat on the same basis. It was a reaction by the nation to the sudden realization that the Soviet Union was a well-developed technological power. The creation of NASA was intended to help the U.S. catch up technologically. Project Apollo was a natural development under those circumstances.

If you talked to the NASA people directing the manned flight program, after the decision was made to begin Project Apollo, and asked them, "Why are we sending men to the moon?" you got a very direct and consistent answer. "Because the President said we were going to put a man on the moon before 1970." It was as simple as that. That was the reason around which the whole program was designed. This goal had a direct effect on the engineering. What was built was a successful system to transport man to the moon and get him back to the earth. The system worked the first time it was used for that purpose.

The Apollo spacecraft is poorly designed, however, for men to work out of, once they get on the moon. That was never a significant part of the goal, and we are now in the embarrassing position of having a system that is very good for getting to the moon and getting back, and difficult to use for anything else.

One of the early decisions, which insured that it would be difficult to explore the moon with the Apollo system, was to adopt the lunar orbital rendezvous mode—that is, to go to the moon by first putting a spacecraft into orbit around the moon and then taking a detachable module down to the moon that later comes back up to rendezvous with the main spacecraft.

The lunar orbital rendezvous mode was chosen, after detailed study, because it was a practical way to meet President Kennedy's goal in the available time and with a launch vehicle of realizable dimensions. The total weight of the spacecraft is significantly reduced by using this mode, in preference to direct descent onto the moon and direct return to earth. But the result was a spacecraft with room for only two pilots in the module that descended to the lunar surface. One pilot had to stay behind to tend the command module in orbit. There is no place in the spacecraft to take along a passenger—someone, for example, who might be a specialist in doing something after he got to the moon, rather than a specialist in flying spacecraft. That possibility was engineered out of the system right at the beginning.

Another difficulty with the Apollo spacecraft is that it is designed for only a very short stay on the moon. The Apollo 11 mission allowed time for one traverse on the lunar surface for both the astronauts. They had time to rest up; then they were off again, and they didn't have much leeway. Had they stayed longer on the lunar surface, they would have exhausted the electrical power and life-support capability of the lunar module. In the next few lunar landings the astronauts will have just two short periods of extravehicular activity.

Still another problem is that working on the lunar surface out of the lunar module is awkward, at best. Simply crawling through the hatch out onto the so-called front porch of the lunar module and climbing down the ladder is time-consuming and cumbersome. There must be better ways for a man to get out of a spacecraft that has landed on the moon. Equipment was transferred from the lunar module cabin to the lunar surface by a method that was primitive, to put it mildly. Armstrong and Aldrin used something like an old clothesline with pulleys. Other scientific equipment was stored inside in a bay that is nominally at shoulder height. With the limitations of the space suits, there was some doubt that it would be physically possible for the astronauts to remove equipment from this bay if the spacecraft landed tilted in the wrong direction or over a little crater on one side.

The lunar orbital rendezvous mode has placed major restrictions on the selection of landing sites on the moon. This limitation arises from the fact that the orbit of the command module tends to remain fixed in orientation;

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because of weight constraints, the command module has only limited capability to change its orbital plane. Meanwhile, the moon is turning all the time. Unless the orbital plane of the command module coincides approximately with the equator of the moon, the lunar module soon drifts out of that plane so far that the fuel required to achieve rendezvous exceeds the capability of the spacecraft. This limitation can be overcome only if the weight of the spacecraft is greatly increased, or if the capability for staying on the lunar surface is increased to a period of a month.

These limitations of the Apollo spacecraft are a few of the consequences of the decision to send men to the moon primarily to develop space technology. They are the consequences of focusing on getting a man to the moon and getting him back, rather than focusing on why he was going to the moon and what he was going to do after he got there. The spacecraft design is not an accident. The men in charge of the manned lunar program genuinely thought that the moon was not a particularly worthwhile place on which to spend much time. They felt it was worth going to the moon once, to show that it could be done, but it was not something to make a practice of. Landing a man on the moon was considered analogous to Lindbergh's flight across the Atlantic. You wouldn't ask Lindbergh to do it a second time.

Not only is there a lack of design in the Apollo spacecraft to carry out lunar exploration, but there has been only minimal preparation for conducting scientific studies in the manned lunar program. Scientists were recruited vigorously at the Manned Spacecraft Center only very late in the game, too late to effectively build up a scientific staff of the size and competence needed. And it was too late to build equipment that would improve the effectiveness of the men on the lunar surface or to prepare the ground facilities adequately to process the samples brought back. The Lunar Sample Receiving Laboratory, for example, was not truly ready to receive samples from the moon. The staff of the Laboratory had been working very hard, but they started preparing five or six years after the Apollo program itself was started. Science was patched onto Apollo very late.

I submit that it is an open question whether it's really worth sending a man into space. We haven't begun to learn how to use men in space effectively. Mercury and Gemini were engineering development programs designed to learn how to get a man into space. Although a few scientific tasks were assigned to the astronauts, no serious effort was made to conduct research in space with the Mercury and Gemini spacecraft. Apollo was supposed to have some science in it, but the astronauts were given many tasks that take minimum advantage of having sent a man to the moon.

The Apollo lunar scientific experiments package consists of a central station with cables that go out to different instruments which have to be set out and oriented by hand. This operation takes about 30 to 45 minutes. If the astronauts were being used effectively, they would set out a package that would deploy itself, or the package would be deployed by remote control or automatically from the lunar module. In fact, the instruments deployed in the Apollo 11 mission and the geophysical instruments planned for the succeeding Apollo flights could have been taken to the moon more readily by an unmanned spacecraft. Had the instruments been ready, every one of them could have been taken to the moon on a Surveyor spacecraft several years back.

Even the task of collecting samples could have been done without men. In the Surveyor program, samples were picked up from the lunar surface and manipulated with a mechanical claw, and a Surveyor-type of spacecraft could also have been built with a capsule to return samples to the earth. Lunar samples could have been collected, probably before Apollo 11, at far smaller cost.

I believe the only purpose for sending man into space that might stand close scrutiny is to explore. Exploration of the solar system is a more fundamental goal that can be set as a major objective for the nation's space program rather than the flexing of our technological muscles. There are some tasks on the surfaces of the moon and other objects in the solar system that man may be able to do better than remotely controlled instruments. Many of these tasks are analogous to the things a field geologist does on earth, although they should be done in a much more sophisticated way than they are usually done on earth. The astronauts' tasks should be planned to utilize his best attributes—his physical dexterity coupled with his visual acuity and his ability to make judgments, to make observations, to decide what to observe next, and to carry out complex tasks using his physical skills.

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If our purpose is to explore the solar system, then we had better start learning how to use man in space. The most propitious place to start is on the moon. If we can't learn how to make advantageous use of men on the moon, then I see no point in sending men to Mars or any more distant place. In that case, there's no point in building an elaborate transportation system.

About ten Apollo spacecraft have been purchased by NASA. Most of them have been built; a few are still on the assembly line. The U.S. also has about ten launch vehicles to send these spacecraft to the moon, and all of the supporting facilities, such as the launch complex at Cape Kennedy, the tracking network, and the people trained to operate them. It seems clear that the prime task for NASA in this next decade is to use these national assets, which have been acquired at great cost, in a way that will provide a maximum return of information from the moon. This means that we need to make modifications to the spacecraft and to develop equipment and supporting techniques to enable the astronauts to carry out efficient scientific exploration.

First of all, the stay-time capability of the Apollo lunar module needs to be increased to many days or a week. Second, the astronauts need life-support systems that will enable them to stay out longer on the lunar surface during each extravehicular activity period. The present systems have limits of useful time of about three hours. That time ought to be improved by at least a factor of two.

Next, the space suits should be greatly improved. A much better suit design is already in hand. On the Apollo 11 mission, because the astronauts could barely bend their knees, they could not readily reach down and pick up something off the surface. They were provided with tongs with a squeezer handle on one end and claws that open and close on the other end with which to pick up rocks. Nearly everything to be done on the surface had to be done with extension handles. The astronauts did move around fairly well on the lunar surface, but it was tiring. The space suits, when pressurized, feel as stiff as a tin can. Considerable energy is expended in bending the suits at the joints. If Armstrong and Aldrin hadn't been in top physical condition, they would not have loped around as they did. It looked easy on television, but they were working hard.

If the astronauts are going to discover the origins of larger features on the moon or investigate and sample a variety of geologic terrain at key localities, they will need some kind of vehicle—a lunar jeep, if you will—to get around. At present they are limited to the relatively short traverses they can accomplish by walking.

If the stay time on the moon is increased and that time is used to visit many different places, automatic systems will be needed to keep track of the astronauts; they shouldn't have to use precious time to locate themselves. Other systems are needed that will return large quantities of field data back to the earth. Portable television systems are good for this; instead of describing what they see, the astronauts can point the camera at it. They can then be supported by an earth-based team of field assistants who compile data as the astronauts go along to help them decide where to go next. The tactics of field geology are essentially going to the right places to make critical observations, then deciding where to go to make the next critical observation.

With the right systems and with earth-based support, experiments conducted by my colleagues in the U.S. Geological Survey indicate that astronauts could obtain the information needed for detailed geological investigation on the moon and do it in a much shorter period of time than is normally taken on earth. It is possible to compress some of the scientific tasks that typically take two or three months into a few days. What we're buying when we put a man on the moon is time for him to do the scientific tasks, so it is essential to do them efficiently.

In short, the first order of business in NASA's manned spaceflight effort should be to reorient the Apollo program to carry out an experiment in scientific exploration. The first returned samples have already shown that the lunar surface is rich in information about the early history of the solar system. In ten missions we should be able to find out whether a man can be used effectively to explore a planetary surface, or whether it would be better to send only unmanned instruments. If, at the end of these missions, the answer is clearly "Yes, it was worth sending the men," then, perhaps, we should start thinking about sending men to Mars. But let's be sure the program is planned to meet the purpose of exploration. I guarantee that it won't be worth sending a man to Mars just to demonstrate the technical feasibility of building a hundred-billion-dollar transportation system.